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## A Virtual Reality Applications Facility for Visualization of Joint Battlespace

Sponsored by: Department of the Air Force Office of Scientific Research

F49620-01-1-0225

Final Performance Report

Jim Bernard, Director Carolina Cruz Neira, Associate Director

Virtual Reality Applications Center Iowa State University

October 4, 2002

#### 1.0 Introduction

The Virtual Reality Applications Center is an interdisciplinary research center administered by the Institute for Physical Research and Technology at Iowa State University. VRAC has become a national leader in the increasingly important field of applications of virtual reality to the challenges of engineering and science.

### **Objective**

The objective of this project was to support command and control embedded training research and development. This effort focused on development of embedded training in a training environment for operational command and control systems. This environment combines live, virtual, and constructive entities, allows war fighters to train individually or collectively at all levels of war, and provides, on demand, realistic training opportunities for command and control operators that mimic the operational environment.

The agreement with ISU was to utilize the C2/C6 facilities at the VRAC to integrate existing DoD simulation training software and collect training effectiveness research data on command and control performance.

The immediate advantages that we expected to realize in connection with the research was that the C2 (now C4) would be a flexible test bed that could be rapidly and inexpensively modified for multiple missions as well as customized for any special or nonstandard mission rehearsal. Additional benefits include the ability to connect the C4 facility to the C6 facility for Virtual Reality (VR) based collaborative training and 3D debriefing for auditorium audiences. These capabilities are directly applicable to the training requirements of the 133ACS in Fort Dodge, Iowa.

Our proposal was for the purchase of equipment to upgrade the VRAC C2 facility to a flexible configuration along with updated projector and visual display equipment. The ability to configure the C2 facility according to the application requirements represented a significant advance in fully immersive virtual reality capability for DoD mission training objectives.

### Final Progress

We opened the new flexible system May 2002 for use in researching virtual reality and collaboration. The "immersive projection" system can create a viewing area as large as 36 feet wide and 9 feet tall, about equal to the display area of 380 standard 17-inch computer monitors. Called the C4, the facility replaces the center's C2 system built in 1996. Like its predecessor, the C4 can also be made into a 12-by-12 foot room with images projected onto three walls as well as the floor. The C4 environment has better, brighter projectors and, within a matter of minutes, we can reconfigure it into one of the largest 3D projection screens in the world. This greatly expands the types of applications we can run.

The system was designed and built in cooperation with Mechdyne Corporation, [of Marshalltown, Iowa. Mechdyne, which has become one of the world's leading suppliers of virtual reality and visualization systems, with a client list that spans six continents and includes

several Fortune 100 and 500 companies. The C4 is driven by high-performance computers from SGI. Because space is limited, images from the projectors are reflected off two mirrors before reaching the screens, a method known as "folded optics." To enable the walls to be swung in and out, projectors are mounted on supports connected to the wall framework. The project also required extensive renovation of the facility, which formerly housed wind-tunnel equipment.

VRAC uses several immersive environments, the largest and highest immersion of these environments are the C4, the C6, and the Lee Liu Auditorium. (see WWW.vrac.iastate.edu.) The C4, C6 and the auditorium systems all project "stereoscopic" images onto large screens. Using special glasses, these images appear three-dimensional to viewers. A tracking system keeps tables on the user's position and orientation to maintain correct prospective as the user "moves" around a virtual space. Three-dimensional sound adds to the realism of the virtual environment.

The new C4 will be particularly valuable in virtual battlespace studies wherein developing the shape of the immersive area is a key part of the research. This new environment also includes a new tracking system, an Ascension Wireless MotionStar. It reports position and orientation data for a user in the C4 without the user being "tethered" to the computer. The new system includes 16 sensors, meaning that up to 16 body points (or other objectives) can be simultaneously tracked.

### **Equipment Purchased**

The C4 is a second generation CAVE that can be used in the traditional CAVE configuration or be modified to create a viewing area as large as 36 feet wide and 10 feet high. This award of \$360,680 was used entirely for the purchase of the flexible screen configuration, virtual reality system (MD-Flex Barco Reality) from the MechDyne Corporation for the new C4.

#### Research

Researchers at VRAC are working on two major defense related projects applying virtual reality interfaces to improve operational readiness and situational awareness. The first of these projects, sponsored by the Air Force Research Lab's Human Effectiveness Directorate, is a two-year investigation of the use of collaborative computer immersion to recreate a Joint Battlespace. The Virtual Battlespace currently under development is a platform for experimentation to determine the positive impact that immersion can have on battlespace management. The project objective is the development and evaluation of a data synthesis and visualization system for battle managers. The system facilitates multi-user, collaborative interaction between participants at a variety of levels of immersion.

The current phase of the investigation involves the development of a multi-user, collaborative system to allow interaction between participants at a variety of levels of immersion. The system will facilitate simultaneous interaction between multiple participants, playing distinct roles at distinct levels of immersion. Combining a traditional 2D desktop user, a user at an immersive desk, a fully immersed user in the C4 or C6, and a group of from 10-200 users in the VRAC stereo auditorium into a common environment will provide us a test bed to evaluate how levels of immersion can be used to increase task performance in a battle environment. Some initial results of this work have been summarized in a paper presented at this years International

IITSEC conference in Lille, France. (Innovative C2 Training Solutions For Air Force Modular Control Systems, Brooks, Breitbach, George)

The second project is a multi-year collaboration between a VRAC research team, the Iowa National Guard and the Iowa Technology Center. The objective of this effort is to investigate, create and evaluate the use of immersive interfaces as tools to improve the operational readiness of Iowa National Guard staff, both Army and Air. Working with domain experts assembled by the Guard and the Iowa Technology Center, Iowa State University (ISU) is leveraging the considerable hardware, software and intellectual resources of ISU's Virtual Reality Applications Center (VRAC) to develop immersive training applications that provide Iowa Guard personnel with a greater breadth and depth of situational experience than would be possible without simulation. Using state of the art computer visualization, ISU is showing how the next generation of human-computer interfaces can be incorporated as an integral and effective component of the system for preparing Iowa Guard personnel for their role in the warfighting machine of the coming decades. The effort is currently directed towards training in the area of command and control, providing Iowa Guard personnel with comprehensive and flexible training simulations. The result will be more realistic training that is cost effective.

### **Summary**

The purchase of the flexible screen configuration helped bring the C4 on line in May 2002. Since that time, work with the C4 and the other VRAC immersive environments have increased to provide support for a wide range of ongoing work, including exciting and innovative defense contracts.

We are grateful to AFOSR for their continuing support.

# Appendix

## **Ongoing Research Projects**

Sponsor	PI	Term	Title	Co-PIs
Air Force		8/21/2000	Title	C. Cruz-
Research Lab		to	Visualization of the	Neira; HA.
(AFRL/IFB)	James Bernard	12/31/2002	Joint Battlespace	Pham
(11112/112)		12/31/2002	Computational	1 Hulli
			Modeling of a	
		8/15/2000	Tangentially Fired	
	Kenneth M.	to	Pulverized Coal	
Alliant Energy	Bryden	8/14/2003	Furnace: Phase 2	
Amant Energy	Dryden	0/14/2003		
			Computational	
		11/1/1000	Modeling of a	
	V annualla M	11/1/1998	Tangentially Fired	
A 11' D	Kenneth M.	to	Pulverized Coal	
Alliant Power	Bryden	12/31/1999	Furnace: Phase I	!
			A Two-tier	
	,	10/1/1000	Computation and	
		10/1/1999	Visualization	
Cornell	Carolina Cruz-	to	Facility for	
University (NSF)	Neira	9/30/2002	Multiscale Problems	
				K. M.
			Synthetic	Bryden; D.
			Environments as	Cook; C.
			Enabling	Cruz-Neira;
			Technology for	J. Dickerson;
		11/1/2001	Product	A. Kelkar;
Deere &		to	Development: Phase	G. Luecke;
Company	James Bernard	10/31/2005	3 (continuation)	J. Vance
				K. M.
			Synthetic	Bryden; D.
			Environments as	Cook; C.
	i		Enabling	Cruz-Neira;
			Technology for	J. Dickerson;
		11/1/2001	Product	A. Kelkar;
Deere &		to	Development: Phase	G. Luecke; J.
Company	James Bernard	10/31/2002	3	Vance
		10/1/1999		
Department of	Kenneth M.	to	Development of	
Energy	Bryden	9/30/2002	Virtual Power Plants	
		8/15/2001	Development of	
	Kenneth M.	to	Rapid Solutions for	
Fuel Tech, Inc.	Bryden	8/15/2005	Reacting Flows	

		T	T	1
7. J TY:11-		0/15/2001	Learner	
Indian Hills	17.	8/15/2001	Connections in	
Community	Kenneth M.	to	Biotechnology:	
College (NSF)	Bryden	6/30/2004	Virtual Bioprocess	
			Military	
Iowa Department		4/1/2001	Applications of	J. Bernard;
of Public		to	Immersive	C. Cruz-
Defense	Adrian Sannier	3/31/2003	Environments	Neira
ISU-Special				
Research				
Initiation Grants		1/1/02-	Ashes to Ashes	C. Cruz-
Competition	Anne Deane	12/31/02		
Compension	Affile Dealle		Driving Project	Neira
		4/6/2001		
John Deere		to	John Deere	1
Foundation	Judy Vance	4/5/2003	Foundation Gift	
			Utilizing Three-	
			Dimensional Data in	•
:			a Virtual Urban	C. Cruz-
			Environment to	Neira; R. G.
		1/1/2001	Support and	Mahayni; D.
National Science		to	Evaluate Planning	Shinn; IS.
Foundation	Chan Chin Chui	12/31/2003	Decisions	
Foundation	Chan, Chiu-Shui	12/31/2003		Suen
			Interactive and	
			Dynamic Visual	
		10/15/1999	Overviews of Large	
National Science		to	Multi-Dimensional	V. Honavar;
Foundation	Dianne H. Cook	9/30/2002	Data	L. Miller
			A Virtual Tornadic	
			Thunderstorm to	
			Enable Student-	
			Centered Learning	
			About Complex	
			Storm-Scale	C Cmyr
National Science		11/1/01		C. Cruz-
National Science	William Caller	11/1/01-	Atmospheric	Neira; C.
Foundation	William Gallus	10/31/03	Dynamics	Cervato
			REU: A Career	
		8/1/1996	Development Plan:	
National Science		to	Research and	
Foundation	Judy Vance	7/31/2002	Teaching	
	-	1	A Career	
		8/15/1996	Development Plan:	
National Science		to	Research and	-
Foundation	Judy Vance	7/31/2002	Teaching	
1 Junuarion	July Vallee	113112002		
		10/1/2000	Interactive Product	
		10/1/2000	Development in a	
National Science		to	Virtual Environment	
Foundation	Judy Vance	9/30/2003	Utilizing Haptics	

			Interactive Product	I
			Development in a	
		8/1/2001	Virtual Environment	
National Science		to	Utilizing Haptics	
Foundation	Judy Vance	9/30/2003	(RET)	
			Wireless	
			Multimedia	
		1/1/2001	Communications for	D. Rover; C.
National Science		to	Virtual	Cruz-Neira;
Foundation	Julie Dickerson	12/31/2003	Environments	R. Weber
			A Virtual Tornadic	
			Thunderstorm to	
			Enable Student-	
			centered Learning	
		2/1/2002	About Complex	
National Colons		2/1/2002	Storm-Scale	C. Cruz-
National Science	William Callan	to	Atmospheric	Neira; C.
Foundation	William Gallus	1/31/2003	Dynamics	Cervato
			Bioinformatic Tools	D. Daulaant
Procter &		8/3/2000	for Extraction and	D. Berleant;
Gamble		to	Modeling of Signal Transduction	J. Dickerson; R. Maddux;
Company	Dan Ashlock	12/31/2002	Networks	E. Wurtele
Company	Dall Ashlock	12/31/2002	Exploration of	E. Wuitele
Procter &		2/1/2002	Finite Element	
Gamble		to	Analysis Data in a	
Company	Judy Vance	1/31/2003	Virtual Environment	
Company	l coop ( mass	1,01,200	Advanced Simulator	
		<u> </u>	Networking for	f
			Vehicle and	
		8/1/2000	Equipment	C. Cruz-
University of		to	Distributed Product	Neira; K. M.
Iowa/NADS	James Bernard	9/30/2002	Design	Bryden
			Multi-Component	
			Harvesting	
		6/21/2001	Equipment for	
US Dept. of	Kenneth M.	to	Inexpensive Sugars	
Energy	Bryden	9/30/2004	from Crop Residues	F. Battaglia
			Analysis and	
	·		Implementation of a	
****		4/28/2001	Tracking Mobile	
Winegard		to	Television Receiver	
Company	Greg Luecke	4/27/2002	(continuation)	